

Fieldbus Cable

by Analog Services, Inc.

Contents:

Cable Characteristics for Fieldbus
Problems With Power/Data on Same Twisted Pair
Simulation of Fieldbus
New Cable Length Data For Foundation Fieldbus
Unbalanced Capacitance in Fieldbus
Length and Unbalanced Capacitance

Foundation Fieldbus is a data communication network for industrial process control instruments. It is intended to replace existing 4-20 mA analog communication and reduce wiring costs by placing several devices on a single twisted-pair cable. **Analog Services, Inc.** has been in the forefront of Fieldbus development. This page is a compilation of several articles related to Fieldbus Cable that previously appeared separately.

1. Cable Characteristics for Fieldbus

This is the title of a paper, authored by Stephen D. Anderson, and published in the IEEE IMTC/92 Conference. It is available through technical libraries and is also available for download [here](#), with permission from the IEEE.

The paper provides measured data on 15 different twisted-pair cables that are representative of instrument cables used in the process control industry. Data presented include transmission line parameters versus frequency and crosstalk versus frequency for frequencies in the range of 1 kHz to 100 kHz. Because these cables were developed for low-frequency analog communication, this information is generally not available from cable manufacturers.

Click [here](#) to download an updated version of this Conference paper as a zipped Microsoft Word document.

2. Problems With Power/Data on Same Twisted Pair

Networks that use the same twisted-pair for both device power and communication present a unique problem. Usually, the power is distributed as DC (or a low frequency), while communication

uses higher frequencies. This is the case for HART and the 31.25 kbits/second Foundation Fieldbus. To distribute power the wire diameter must be relatively large (low gauge). But, to facilitate the higher frequency communication, the capacitance per unit length should be low. Unfortunately, most existing cable satisfies one or the other of these requirements but not both. Low-capacitance cable designed for data comm seems to be found mainly in the #24 to #26 gauge range, while the cable needed to distribute power is in the #18 to #20 range. The general effect of higher capacitance is to reduce the acceptable length of network cable.

Cable manufacturers have been slow to respond to the need for a heavy gauge, low-capacitance cable; even though there seem to be no technical roadblocks. This is a puzzling situation that has existed for some years and may have to do with Fieldbus and HART being process control-related. Perhaps the cable manufacturers believe that they have this market segment "covered" and don't need to do anything further.

Another problem with respect to Fieldbus and other differential signaling methods is that multi-pair instrument cable is not well color-coded. You can't tell from the colors which wire belongs to which pair. When the outer jacket is first removed, the two wires comprising each pair are apparent. But later on, when the two wires of the pair are unraveled during wiring, the pair identification is lost.

3. Simulation of Fieldbus

What if you could build and test every network that your customers/end-users might string together? If you could, you'd know whether some configurations cause poor received signals, such as too much attenuation or too much delay distortion. You'd know the effect of a missing terminator or too many terminators. And you'd know whether you're allowing too long a cable, too many devices, or too great a concentration of drop cables.

Developers of every new cable-based LAN face these questions when devising network configuration rules. The rules hopefully tell the customer/end-user what to put where, so that a poor signal is avoided. Because we can't build every conceivable network, the rules are often addressed through guesses, rules of thumb, experience with previous networks, and/or analyses of a few simple configurations.

A better way is to use simulation. Using simulation, we can "build" a very large number of networks with random cables, random cable lengths, random drop locations, etc. We can check the transfer function between every pair of networked devices and determine a worst-case transfer function. This worst-case transfer function can then be used to generate eye diagrams, scatter plots, etc. for received data symbols.

During the 1980's **Analog Services, Inc.** developed software to do exactly these kinds of simulations. This approach to network analysis was used extensively in investigations of Foundation Fieldbus, a network for industrial process control instruments. A key feature of the simulation software is the modeling of every cable segment as a doubly-terminated transmission line.

We have received permission from Fisher-Rosemount Inc. (Austin, TX) to publish the original report on this work. Click [here](#) to see the report.

We have also been given permission by Fisher-Rosemount Inc. (Austin, TX) to publish the simulation software. You can download it by clicking [here](#). It is in the form of a Fortran source file. Contact Analog Services, Inc. (see below) if you have questions regarding this file.

4. New Cable Length Data For Foundation Fieldbus

At present the Physical Layer Specification has several statements about cable length limits. Clause 22.2.2, Rule 2 states that there is maximum cable length of 1900 meter (6230 feet) between any two devices in a fully loaded (32 devices) network. But, following this it also says (Clause 22.2.2, Note 2) that "this does not preclude the use of longer lengths in an installed system." And in Annex C.2 it recommends limits on spur (drop) lengths based on their number. Thus, there are several parts of the document that are related in some way to limiting cable length; with 1900 meter as either a definite length limit or at least the focus of attention.

Fieldbus users would like to see the 1900 meter limit increased, if possible. It is generally thought that the existing specification is quite conservative and that the length limit probably can be increased -- especially in circumstances where there are few networked devices. We note, also, that specifications such as this are often attempts to guarantee operation at the extremes of tolerances, installation, etc.; and that a more flexible type of specification may be desired.

Analog Services, Inc. recently completed simulations to determine whether 1900 meter constitutes an appropriate length limit or whether, and under what circumstances, it might be increased. These new simulations were designed (1) to examine the 1900 meter length limit for Type A cable and (2) to determine trade-offs, if any, between number of devices and length of cable. You can download a complete report on these simulations by [clicking here](#). The report is in the form of a zipped Microsoft Word file. The results are presented in the form of tables showing the effect of various trunk and spur lengths. Among the findings are that trunk lengths of up to 3000 meter should be possible in many cases. This report is made available with permission from Fisher-Rosemount Inc. (Austin, TX).

5. Unbalanced Capacitance in Fieldbus

Analog Services, Inc. recently completed an analysis of capacitance unbalance (CUB) in Fieldbus cable. Fieldbus is intended to use balanced signaling; as in telephone lines, RS485 lines, etc. This reduces crosstalk and coupled interference. The extent of these disturbances is determined by the degree of unbalance. Thus, the Fieldbus specification includes an upper limit on CUB in cables (and in other devices).

One source of interference is ground potential difference. Although this may be quite large at 50/60 Hz, it is believed to drop off considerably at Fieldbus signaling frequencies (7.8 kHz to 39 kHz). Assuming that in-band ground potential difference is relatively small, the cable CUB specification can be relaxed. Our report on this analysis recommends that the cable CUB be increased from 4 nF/km to 20 nF/km. You can download the complete report by [clicking here](#). The report is in the form of a zipped Microsoft Word file. This report is made available with permission

from Fisher-Rosen Count Inc. (Austin, TX).

6. Length and Unbalanced Capacitance

Since the length and unbalance analyses were done more or less independently, the question arises as to whether they effect each other. That is, does an unusually large amount of cable cause greater circuit unbalance -- perhaps requiring a smaller CUB than was recommended? The answer is no. The data show that the effect of CUB goes through a maximum at intermediate lengths of cable. With no cable, the unbalance is controlled by devices and the normal-mode voltage is low. As cable is added the normal-mode voltage increases to a maximum. Then, as more cable is added, the normal-mode voltage drops.

For more information on how Analog Services, Inc. can help solve your circuit/system problems, call or e-mail us today.

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[technical literature index](#)

[home](#)